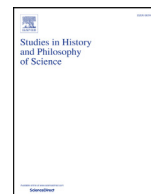




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Out of the fog: Catalyzing integrative capacity in interdisciplinary research

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ABSTRACT

Social studies of interdisciplinary science investigate how scientific collaborations approach complex challenges that require multiple disciplinary perspectives. In order for collaborators to meet these complex challenges, interdisciplinary collaborations must develop and maintain integrative capacity, understood as the ability to anticipate and weigh tradeoffs in the employment of different disciplinary approaches. Here we provide an account of how one group of interdisciplinary fog scientists intentionally catalyzed integrative capacity. Through conversation, collaborators negotiated their commitments regarding the ontology of fog systems and the methodologies appropriate to studying fog systems, thereby enhancing capabilities which we take to constitute integrative capacity. On the ontological front, collaborators negotiated their commitments by setting boundaries to and within the system, layering different subsystems, focusing on key intersections of these subsystems, and agreeing on goals that would direct further investigation. On the methodological front, collaborators sequenced various methods, anchored methods at different scales, validated one method with another, standardized the outputs of related methods, and coordinated methods to fit a common model. By observing the process and form of collaborator conversations, this case study demonstrates that social studies of science can bring into critical focus how interdisciplinary collaborators work toward an integrated conceptualization of study systems.

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1. Introduction

In this essay, we present a case study in interdisciplinary integration involving a large group of scientists who share a research interest in fog science. We focus on the early stages of this group's effort to create an interdisciplinary research (IDR) community. In these early stages, which comprised a workshop and the leadership meetings that designed it, most of the scientists in the group were unfamiliar with one another and were pursuing their disciplinary fog projects independently. Our attention is directed to the development by this newly formed group of the collective capacity to pursue interdisciplinary integration. Following Salazar, Lant, Fiore,

and Salas (2012), we call this *integrative capacity* and understand it to be the capacity of a group to conduct research that effectively synthesizes contributions from different disciplines.¹

Our examination is related to work on team coordination (e.g., Entin & Serfaty, 1999; Leedom & Simon, 1995) and macrocognition (e.g., Fiore, Smith-Jentsch, Salas, Warner, & Letsky, 2010; Letsky & Warner, 2008) which has been the focus of extensive investigation in organizational studies, small group research, military

¹ Salazar et al. (2012) define *integrative capacity* as "a capability that is sustained through an interactive system linking social, psychological, and cognitive processes" (p. 528; cf. Nersessian, 2004). In this article, we focus on the conceptual dimensions of integrative capacity formation. While related most closely to the cognitive processes that Salazar et al. discuss, these dimensions expand our understanding of integrative capacity beyond what they consider. For more discussion of integrative capacity, see §2.1 below.

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psychology, and education; in this article, we expand on these discussions by describing specific collaborative capabilities that contribute to the integration of disciplinary knowledge in a particular scientific project. These capabilities support collaborative reasoning, understood as collective consideration of disciplinary contributions that emphasizes similarities, differences, and implications (cf. Hogan, 1999; Nussbaum, 2008). Given their influence on scientific reasoning, these capabilities shape the collaborative decision-making that integrates disciplinary contributions and pushes a collaborative, interdisciplinary project forward (cf. Hall & O'Rourke, 2014; Lang et al., 2012).

We have adopted ethnographic methods for the purpose of this study, and we follow Rehg and Staley (2008) in arguing that “philosophical analysis can achieve practical relevance through the interdisciplinary study of scientific activity as a set of argumentative practices” (p. 2). Consistent with Galison (1997), Rehg and Staley (2008), and Tsoukas (2009), we explore how dialog contributes to scientific understanding. Our observations were directed primarily at the conversations involving the project leadership in advance of the workshop and the conversations among the scientists at the workshop. These discourses constituted an important context for disclosing, expanding, and negotiating different perspectives on fog science and supplied a discursive foundation for the development of integrative capacity (cf. Keyton, Ford, & Smith, 2008; Nussbaum, 2008).² After describing the conceptual, scientific, and project background of our case study and our ethnographic methods, we discuss a process diagram for integrative capacity that highlights capabilities cultivated within the emerging coastal fog community. We conclude by considering the implications of our case study for those who share our broader interest in interdisciplinary integration.

2. Background: concept, topic, project

This essay is a case study of an intentional effort to create a community of investigators who could participate in collaborative IDR, and as such is a contribution to the growing literature that concerns the theory and practice of IDR. We take as our problem the underdeveloped nature of our understanding of successful interdisciplinary integration; in particular, more must be done to identify the capabilities an IDR collaboration should have to support the successful integration of its various perspectives (Klein, 2012; O'Rourke, Crowley, & Gonnerman, 2015; Salazar et al., 2012). This case study aims to enhance our understanding of these capabilities, and in particular how these capabilities can be developed over time by a newly formed interdisciplinary collaboration. In this section, we describe the background of our case study analysis, focusing on the concepts that frame our engagement with the case, the topics that have received scientific attention, and the Coastal Fog as a System project.

2.1. Conceptual background

Collaborative IDR is IDR, and as such it involves bringing disciplinary inputs together into integrative relations (e.g., *linking, synthesizing, reducing*) that yield an output understood as a whole (O'Rourke et al., 2015). So understood, integration has been called the “primary methodology of interdisciplinarity” (Klein, 2012, p.

283), a sign of its centrality in current thinking about how IDR is conducted. Klein (2012) notes that in the past several decades, interdisciplinarity has grown synonymous with complex problem-solving. Problems serve to frame the combination of disciplinary perspectives, often guiding selection of one discipline among those represented in a project on which to “center” the investigation, structuring trade-offs and decision making as collaborators pursue a unified response (Hall & O'Rourke, 2014). While the “discourse of problem solving” (Klein, 2014) applies to many aspects of IDR, not all interdisciplinary work focuses on an identified problem held in common by collaborators. In some cases, interdisciplinary collaborations form in advance of identifying a problem, with people drawn together from different disciplines by common interests, a common dataset, and/or the desire to conduct collaborative research. In other cases, investigators from different disciplines are motivated by their own conception of the problem; here, an early interdisciplinary phase of the research could involve interdisciplinary negotiation aimed at creating a common conception of the problem (Morse, 2013; cf. Holbrook, 2013). Further, IDR collaborations that find success together often move from problem to problem over their lifetimes, remaining intact during the liminal periods when new research problems are sought (Thoren & Persson, 2013).

Interdisciplinary activities like these call attention to a distinction central to our analysis—while integration is a mark of interdisciplinary success when we consider research on a specific problem, unified responses to problems are also an indication of *integrative capacity* (Salazar et al., 2012). This capacity is analogous to collaborative capacity (Foster-Fishman, Berkowitz, Lounsbury, Jacobson, & Allen, 2001) or collective communication competence (Thompson, 2009) in that it is a set of capabilities that reliably enables the effective combination of disciplinary insights in research decision-making. In subsequent sections we provide a detailed sketch of integrative capacity in the context of a particular interdisciplinary effort, but there are several features that integrative capacity exhibits in the context of collaborative IDR considered more generally. First, like collaborative capacity, integrative capacity can be acquired, built, and improved. Newly formed groups may include successful interdisciplinary researchers, but the acquisition of collaborative integrative capacity will be hastened by the development of joint decision-making capabilities and the capabilities to reason in coordinated and mutually responsive ways (cf. Bratman, 2014).³ These collective capabilities take time to develop and will typically be hard won in the course of grappling with problems that require the integration of disciplinary inputs for their success. Second, integrative capacity requires the capability to disintegrate as well as integrate—it can be demonstrated in the context of analysis as well as synthesis, such as when an attempt at interdisciplinary synthesis fails and must be undone before the group can continue (O'Malley, 2013). Third, it doesn't require that the group agree; in fact, leveraging disagreement will likely be an important part of interdisciplinary success in many cases, as these moments will highlight disciplinary differences and can often reveal new opportunities for negotiated integration (Lovelace,

² We view these conversations as themselves scientific practice as opposed to being conversations *about* scientific practice, which can often produce a misleading picture of how science works (Knorr-Cetina, 1999; Latour, 2000). These conversations shaped the initial conditions for the practice of coastal fog science, but the science will indubitably shift as researchers confront concrete challenges in the lab and field.

³ These joint decision-making capabilities can be understood as constituting a capacity for *shared deliberation*. A key part of his account of shared agency, Bratman (2014) argues that shared deliberation exhibits an “interplay between three forms of shared intention”: it occurs in the context of shared intentional activity, it is itself a shared action, and it occurs against a background of shared commitments to weigh key aspects of the decision space in similar ways (p. 134). (For Bratman, shared intentions are interrelated attitudes that “interpersonally structure and coordinate thought and action” (p. 34).) This detailed account supplies one model of the capacity for coordinated and mutually responsive reasoning manifested by IDR teams.

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